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## THE INTERNAL CONSTITUTION OF THE STARS<sup>1</sup>

LAST year at Bournemouth we listened to a proposal from the president of the association to bore a hole in the crust of the earth and discover the conditions deep down below the surface. This proposal may remind us that the most secret places of nature are, perhaps, not 10 to the  $n$ -th miles above our heads, but 10 miles below our feet. In the last five years the outward march of astronomical discovery has been rapid, and the most remote worlds are now scarcely safe from its inquisition. By the work of H. Shapley the globular clusters, which are found to be at distances scarcely dreamed of hitherto, have been explored, and our knowledge of them is in some respects more complete than that of the local aggregation of stars which includes the sun. Distance lends not enchantment but precision to the view. Moreover, theoretical researches of Einstein and Weyl make it probable that the space which remains beyond is not illimitable; not merely the material universe, but space itself, is perhaps finite; and the explorer must one day stay his conquering march for lack of fresh realms to invade. But to-day let us turn our thoughts inwards to that other region of mystery—a region cut off by more substantial barriers, for, contrary to many anticipations, even the discovery of the fourth dimension has not enabled us to get at the inside of a body. Science has material and non-material appliances to bore into the interior, and I have chosen to devote this address to what may be described as analytical boring devices—*absit omen!*

The analytical appliance is delicate at present, and, I fear, would make little headway against the solid crust of the earth. Instead

<sup>1</sup> Address before the Mathematical and Physical Science Section of the British Association for the Advancement of Science.



of letting it blunt itself against the rocks, let us look round for something easier to penetrate. The sun? Well, perhaps. Many have struggled to penetrate the mystery of the interior of the sun; but the difficulties are great, for its substance is denser than water. It may not be quite so bad as Biron makes out in "Love's Labour's Lost":

The heaven's glorious sun;  
That will not be deep-searched with saucy looks;  
Small have continual plodders ever won  
Save base authority from others' books.

But it is far better if we can deal with matter in that state known as a perfect gas, which charms away difficulties as by magic. Where shall it be found?

A few years ago we should have been puzzled to say where, except perhaps in certain nebulae; but now it is known that abundant material of this kind awaits investigation. Stars in a truly gaseous state exist in great numbers, although at first sight they are scarcely to be discriminated from dense stars like our sun. Not only so, but the gaseous stars are the most powerful light-givers, so that they force themselves on our attention. Many of the familiar stars are of this kind—Aldebaran, Canopus, Arcturus, Antares; and it would be safe to say that three quarters of the naked-eye stars are in this diffuse state. This remarkable condition has been made known through the researches of H. N. Russell and E. Hertzsprung; the way in which their conclusions, which ran counter to the prevailing thought of the time, have been substantiated on all sides by overwhelming evidence, is the outstanding feature of recent progress in stellar astronomy.

The diffuse gaseous stars are called *giants*, and the dense stars are called *dwarfs*. During the life of a star there is presumably a gradual increase of density through contraction, so that these terms distinguish the earlier and later stages of stellar history. It appears that a star begins its effective life as a giant of comparatively low temperature—a red or M-type star. As this diffuse mass of gas contracts its temperature must rise, a conclusion long ago pointed out by Homer Lane. The

rise continues until the star becomes too dense, and ceases to behave as a perfect gas. A maximum temperature is attained, depending on the mass, after which the star, which has now become a dwarf, cools and further contracts. Thus each temperature-level is passed through twice, once in an ascending and once in a descending stage—once as a giant, once as a dwarf. Temperature plays so predominant a part in the usual spectral classification that the ascending and descending stars were not originally discriminated, and the customary classification led to some perplexities. The separation of the two series was discovered through their great difference in luminosity, particularly striking in the case of the red and yellow stars, where the two stages fall widely apart in the star's history. The bloated giant has a far larger surface than the compact dwarf, and gives correspondingly greater light. The distinction was also revealed by direct determinations of stellar densities, which are possible in the case of eclipsing variables like Algol. Finally, Adams and Kohlschütter have set the seal on this discussion by showing that there are actual spectral differences between the ascending and descending stars at the same temperature-level, which are conspicuous enough—when they are looked for.

Perhaps we should not too hastily assume that the direction of evolution is necessarily in the order of increasing density, in view of our ignorance of the origin of a star's heat, to which I must allude later. But, at any rate, it is a great advance to have disentangled what is the true order of continuous increase of density, which was hidden by superficial resemblances.

The giant stars, representing the first half of a star's life, are taken as material for our first boring experiment. Probably, measured in time, this stage corresponds to much less than half the life, for here it is the ascent which is easy and the way down is long and slow. Let us try to picture the conditions inside a giant star. We need not dwell on the vast dimensions—a mass like that of the sun, but swollen to much greater volume on account of the low density, often below that of our own atmos-



phere. It is the star as a storehouse of heat which especially engages our attention. In the hot bodies familiar to us the heat consists in the energy of motion of the ultimate particles, flying at great speeds hither and thither. So too in the stars a great store of heat exists in this form; but a new feature arises. A large proportion, sometimes more than half the total heat, consists of imprisoned radiant energy—ether-waves travelling in all directions trying to break through the material which encages them. The star is like a sieve, which can only retain them temporarily; they are turned aside, scattered, absorbed for a moment, and flung out again in a new direction. An element of energy may thread the maze for hundreds of years before it attains the freedom of outer space. Nevertheless the sieve leaks, and a steady stream permeates outwards, supplying the light and heat which the star radiates all round.

That some ethereal heat as well as material heat exists in any hot body would naturally be admitted; but the point on which we have here to lay stress is that in the stars, particularly in the giant stars, the ethereal portion rises to an importance which quite transcends our ordinary experience, so that we are confronted with a new type of problem. In a red-hot mass of iron the ethereal energy constitutes less than a billionth part of the whole; but in the tussle between matter and ether the ether gains a larger and larger proportion of the energy as the temperature rises. This change in proportion is rapid, the ethereal energy increasing rigorously as the fourth power of the temperature, and the material energy roughly as the first power. But even at the temperature of some millions of degrees attained inside the stars there would still remain a great disproportion; and it is the low density of material, and accordingly reduced material energy per unit volume in the giant stars, which wipes out the last few powers of 10. In all the giant stars known to us, widely as they differ from one another, the conditions are just reached at which these two varieties of heat-energy have attained a rough equality; at any rate one can not be neglected compared

with the other. Theoretically there could be conditions in which the disproportion was reversed and the ethereal far out-weighed the material energy; but we do not find them in the stars. It is as though the stars had been measured out—that their sizes had been determined—with a view to this balance of power; and one can not refrain from attributing to this condition a deep significance in the evolution of the cosmos into separate stars.

Study of the radiation and internal conditions of a star brings forward very pressingly a problem often debated in this section: What is the source of the heat which the sun and stars are continually squandering? The answer given is almost unanimous—that it is obtained from the gravitational energy converted as the star steadily contracts. But almost as unanimously this answer is ignored in its practical consequences. Lord Kelvin showed that this hypothesis, due to Helmholtz, necessarily dates the birth of the sun about 20,000,000 years ago; and he made strenuous efforts to induce geologists and biologists to accommodate their demands to this time-scale. I do not think they proved altogether tractable. But it is among his own colleagues, physicists and astronomers, that the most outrageous violations of this limit have prevailed. I need only refer to Sir George Darwin's theory of the earth-moon system, to the present Lord Rayleigh's determination of the age of terrestrial rocks from occluded helium, and to all modern discussions of the statistical equilibrium of the stellar system. No one seems to have any hesitation, if it suits him, in carrying back the history of the earth long before the supposed date of formation of the solar system; and in some cases at least this appears to be justified by experimental evidence which it is difficult to dispute. Lord Kelvin's date of the creation of the sun is treated with no more respect than Archbishop Ussher's.

The serious consequences of this contraction hypothesis are particularly prominent in the case of giant stars, for the giants are prodigal

with their heat and radiate at least a hundred times as fast as the sun. The supply of energy which suffices to maintain the sun for 10,000,000 years would be squandered by a giant star in less than 100,000 years. The whole evolution in the giant stage would have to be very rapid. In 18,000 years at the most a typical star must pass from the initial M stage to type G. In 80,000 years it has reached type A, near the top of the scale, and is about to start on the downward path. Even these figures are probably very much overestimated. Most of the naked-eye stars are still in the giant stage. Dare we believe that they were all formed within the last 80,000 years? The telescope reveals to us objects not only remote in distance but remote in time. We can turn it on a globular cluster and behold what was passing 20,000, 50,000, even 200,000 years ago—unfortunately not all in the same cluster, but different clusters representing different epochs of the past. As Shapley has pointed out, the verdict appears to be “no change.” This is perhaps not conclusive, because it does not follow that individual stars have suffered no change in the interval; but it is difficult to resist the impression that the evolution of the stellar universe proceeds at a slow, majestic pace, with respect to which these periods of time are insignificant.

There is another line of astronomical evidence which appears to show more definitely that the evolution of the stars proceeds far more slowly than the contraction hypothesis allows; and perhaps it may ultimately enable us to measure the true rate of progress. There are certain stars, known as Cepheid variables, which undergo a regular fluctuation of light of a characteristic kind, generally with a period of a few days. This light change is *not* due to eclipse. Moreover, the color quality of the light changes between maximum and minimum, evidently pointing to a periodic change in the physical condition of the star. Although these objects were formerly thought to be double stars, it now seems clear that this was a misinterpretation of the spectroscopic evidence. There is in fact no room for the hypothetical companion star; the orbit is so small

that we should have to place it inside the principal star. Everything points to the period of the light pulsation being something intrinsic in the star; and the hypothesis advocated by Shapley, that it represents a mechanical pulsation of the star, seems to be the most plausible. I have already mentioned that the observed period does in fact agree with the calculated period of mechanical pulsation, so that the pulsation explanation survives one fairly stringent test. But whatever the cause of the variability, whether pulsation or rotation, provided only that it is intrinsic in the star, and not forced from outside, the density must be the leading factor in determining the period. If the star is contracting so that its density changes appreciably, the period can not remain constant. Now, on the contraction hypothesis the change of density must amount to at least 1 per cent. in 40 years. (I give the figures for  $\delta$  Cephei, the best-known variable of this class.) The corresponding change of period should be very easily detectable. For  $\delta$  Cephei the period ought to decrease 40 seconds annually.

Now  $\delta$  Cephei has been under careful observation since 1785, and it is known that the change of period, if any, must be very small. S. Chandler found a decrease of period of  $\frac{1}{20}$  second per annum, and in a recent investigation E. Hertzsprung has found a decrease of  $\frac{1}{40}$  second per annum. The evidence that there is any decrease at all rests almost entirely on the earliest observations made before 1800, so that it is not very certain; but in any case the evolution is proceeding at not more than  $\frac{1}{400}$  of the rate required by the contraction hypothesis. There must at this stage of the evolution of the star be some other source of energy which prolongs the life of the star 400-fold. The time-scale so enlarged would suffice for practically all reasonable demands.

I hope the dilemma is plain. Either we must admit that whilst the density changes 1 per cent, a certain period intrinsic in the star can change no more than  $\frac{1}{800}$  of 1 per cent., or we must give up the contraction hypothesis.



If the contraction theory were proposed to-day as a novel hypothesis I do not think it would stand the smallest chance of acceptance. From all sides—biology, geology, physics, astronomy—it would be objected that the suggested source of energy was hopelessly inadequate to provide the heat spent during the necessary time of evolution; and, so far as it is possible to interpret observational evidence confidently, the theory would be held to be definitely negative. Only the inertia of tradition keeps the contraction hypothesis alive—or rather, not alive, but an unburied corpse. But if we decide to inter the corpse, let us frankly recognize the position in which we are left. A star is drawing on some vast reservoir of energy by means unknown to us. This reservoir can scarcely be other than the sub-atomic energy which, it is known, exists abundantly in all matter; we sometimes dream that man will one day learn how to release it and use it for his service. The store is well-nigh inexhaustible, if only it could be tapped. There is sufficient in the sun to maintain its output of heat for 15 billion years.

Certain physical investigations in the past year, which I hope we may hear about at this meeting, make it probable to my mind that some portion of this sub-atomic energy is actually being set free in the stars. F. W. Aston's experiments seem to leave no room for doubt that all the elements are constituted out of hydrogen atoms bound together with negative electrons. The nucleus of the helium atom, for example, consists of 4 hydrogen atoms bound with 2 electrons. But Aston has further shown conclusively that the mass of the helium atom is less than the sum of the masses of the 4 hydrogen atoms which enter into it; and in this at any rate the chemists agree with him. There is a loss of mass in the synthesis amounting to about 1 part in 120, the atomic weight of hydrogen being 1.008 and that of helium just 4. I will not dwell on his beautiful proof of this, as you will no doubt be able to hear it from himself. Now mass can not be annihilated, and the deficit can only represent the mass of the

electrical energy set free in the transmutation. We can therefore at once calculate the quantity of energy liberated when helium is made out of hydrogen. If 5 per cent, of a star's mass consists initially of hydrogen atoms, which are gradually being combined to form more complex elements, the total heat liberated will more than suffice for our demands, and we need look no further for the source of a star's energy.

But is it possible to admit that such a transmutation is occurring? It is difficult to assert, but perhaps more difficult to deny, that this is going on. Sir Ernest Rutherford has recently been breaking down the atoms of oxygen and nitrogen, driving out an isotope of helium from them; and what is possible in the Cavendish laboratory may not be too difficult in the sun. I think that the suspicion has been generally entertained that the stars are the crucibles in which the lighter atoms which abound in the nebulae are compounded into more complex elements. In the stars matter has its preliminary brewing to prepare the greater variety of elements which are needed for a world of life. The radio-active elements must have been formed at no very distant date; and their synthesis, unlike the generation of helium from hydrogen, is endothermic. If combinations requiring the addition of energy can occur in the stars, combinations which liberate energy ought not to be impossible.

We need not bind ourselves to the formation of helium from hydrogen as the sole reaction which supplies the energy, although it would seem that the further stages in building up the elements involve much less liberation, and sometimes even absorption, of energy. It is a question of accurate measurement of the deviations of atomic weights from integers, and up to the present hydrogen is the only element for which Mr. Aston has been able to detect the deviation. No doubt we shall learn more about the possibilities in due time. The position may be summarized in these terms: the atoms of all elements are built of hydrogen atoms bound together, and presumably have at one time been formed

from hydrogen; the interior of a star seems as likely a place as any for the evolution to have occurred; whenever it did occur a great amount of energy must have been set free; in a star a vast quantity of energy is being set free which is hitherto unaccounted for. You may draw a conclusion if you like.

If, indeed, the sub-atomic energy in the stars is being freely used to maintain their great furnaces, it seems to bring a little nearer to fulfilment our dream of controlling this latent power for the well-being of the human race—or for its suicide.

So far as the immediate needs of astronomy are concerned, it is not of any great consequence whether in this suggestion we have actually laid a finger on the true source of the heat. It is sufficient if the discussion opens our eyes to the wider possibilities. We can get rid of the obsession that there is no other conceivable supply besides contraction, but we need not again cramp ourselves by adopting prematurely what is perhaps a still wilder guess. Rather we should admit that the source is not certainly known, and seek for any possible astronomical evidence which may help to define its necessary character. One piece of evidence of this kind may be worth mentioning. It seems clear that it must be the high temperature inside the stars which determines the liberation of energy, as H. N. Russell has pointed out. If so the supply may come mainly from the hottest region at the center. I have already stated that the general uniformity of the opacity of the stars is much more easily intelligible if it depends on scattering rather than on true absorption; but it did not seem possible to reconcile the deduced stellar opacity with the theoretical scattering coefficient. Within reasonable limits it makes no great difference in our calculations at what parts of the star the heat energy is supplied, and it was assumed that it comes more or less evenly from all parts, as would be the case on the contraction theory. The possibility was scarcely contemplated that the energy is supplied entirely in a restricted region round the center. Now, the more concentrated the supply, the lower

is the opacity requisite to account for the observed radiation. I have not made any detailed calculations, but it seems possible that for a sufficiently concentrated source the deduced and the theoretical coefficients could be made to agree, and there does not seem to be any other way of accomplishing this. Conversely, we might perhaps argue that the present discrepancy of the coefficients shows that the energy supply is not spread out in the way required by the contraction hypothesis, but belongs to some new source only available at the hottest, central part of the star.

I should not be surprised if it is whispered that this address has at times verged on being a little bit speculative; perhaps some outspoken friend may bluntly say that it has been highly speculative from beginning to end. I wonder what is the touchstone by which we may test the legitimate development of scientific theory and reject the idly speculative. We all know of theories which the scientific mind instinctively rejects as fruitless guesses; but it is difficult to specify their exact defect or to supply a rule which will show us when we ourselves do err. It is often supposed that to speculate and to make hypotheses are the same thing; but more often they are opposed. It is when we let our thoughts stray outside venerable, but sometimes insecure, hypotheses that we are said to speculate. Hypothesis limits speculation. Moreover, distrust of speculation often serves as a cover for loose thinking; wild ideas take anchorage in our minds and influence our outlook; whilst it is considered too speculative to subject them to the scientific scrutiny which would exercise them.

If we are not content with the dull accumulation of experimental facts, if we make any deductions or generalizations, if we seek for any theory to guide us, some degree of speculation can not be avoided. Some will prefer to take the interpretation which seems to be most immediately indicated and at once adopt that as an hypothesis; others will rather seek to explore and classify the widest possibilities which are not definitely inconsistent with the facts. Either choice has its dangers; the first



may be too narrow a view and lead progress into a cul-de-sac; the second may be so broad that it is useless as a guide, and diverges indefinitely from experimental knowledge. When this last case happens, it must be concluded that the knowledge is not yet ripe for theoretical treatment and speculation is premature. The time when speculative theory and observational research may profitably go hand in hand is when the possibilities, or at any rate the probabilities, can be narrowed down by experiment, and the theory can indicate the tests by which the remaining wrong paths may be blocked up one by one.

The mathematical physicist is in a position of peculiar difficulty. He may work out the behavior of an ideal model of material with specifically defined properties, obeying mathematically exact laws, and so far his work is unimpeachable. It is no more speculative than the binomial theorem. But when he claims a serious interest for his toy, when he suggests that his model is like something going on in Nature, he inevitably begins to speculate. Is the actual body really like the ideal model? May not other unknown conditions intervene? He can not be sure, but he can not suppress the comparison; for it is by looking continually to Nature that he is guided in his choice of a subject. A common fault, to which he must often plead guilty, is to use for the comparison data over which the more experienced observer shakes his head; they are too insecure to build extensively upon. Yet even in this, theory may help observation by showing the kind of data which it is especially important to improve.

I think that the more idle kinds of speculation will be avoided if the investigation is conducted from the right point of view. When the properties of an ideal model have been worked out by rigorous mathematics, all the underlying assumptions being clearly understood, then it becomes possible to say that such properties and laws lead precisely to such and such effects. If any other disregarded factors are present, they should now betray themselves when a comparison is made with Nature. There is no need for disap-

pointment at the failure of the model to give perfect agreement with observation; it has served its purpose, for it has distinguished what are the features of the actual phenomena which require new conditions for their explanation. A general preliminary agreement with observation is necessary, otherwise the model is hopeless; not that it is necessarily wrong so far as it goes, but it has evidently put the less essential properties foremost. We have been pulling at the wrong end of the tangle, which has to be unravelled by a different approach. But after a general agreement with observation is established, and the tangle begins to loosen, we should always make ready for the next knot. I suppose that the applied mathematician whose theory has just passed one still more stringent test by observation ought not to feel satisfaction, but rather disappointment—"Foiled again! This time I *had* hoped to find a discordance which would throw light on the points where my model could be improved." Perhaps that is a counsel of perfection; I own that I have never felt very keenly a disappointment of this kind.

Our model of Nature should not be like a building—a handsome structure for the populace to admire, until in the course of time some one takes away a corner stone and the edifice comes toppling down. It should be like an engine with movable parts. We need not fix the position of any one lever; that is to be adjusted from time to time as the latest observations indicate. The aim of the theorist is to know the train of wheels which the lever sets in motion—that binding of the parts which is the soul of the engine.

In ancient days two aviators procured to themselves wings. Dædalus flew safely through the middle air across the sea, and was duly honored on his landing. Young Icarus soared upwards towards the sun till the wax melted which bound his wings, and his flight ended in fiasco. In weighing their achievements perhaps there is something to be said for Icarus. The classic authorities tell us that he was only "doing a stunt," but I prefer to think of him as the man who

certainly brought to light a constructional defect in the flying machines of his day. So too in science. Cautious Dædalus will apply his theories where he feels most confident they will safely go; but by his excess of caution their hidden weakness can not be brought to light. Icarus will strain his theories to the breaking-point till the weak joints gape. For a spectacular stunt? Perhaps partly; he is often very human. But if he is not yet destined to reach the sun and solve for all time the riddle of its constitution, yet he may hope to learn from his journey some hints to build a better machine.

A. S. EDDINGTON

### THE HAWAIIAN OLONA

IN SCIENCE (N. S. 48: 236-38, September 6, 1918) was published a paper by the writer, entitled "The Olona, Hawaii's Unexcelled Fiber Plant." This was later reprinted by the *Literary Digest*, and evidently aroused widespread interest concerning this remarkable fiber. The writer received letters from many parts of the world, requesting further information. Since his previous account he has been furnished with the following statement, by Dr. N. Russel, of Olona, Hawaii, and originally published in the report of the Hawaii Agricultural Experiment Station for 1902. As this report is out-of-print and unavailable to most students, Russel's excellent account is presented herewith:

Some fifty years ago about 1,000 natives were living on the margin of the virgin forest and pahoe-hoe rock along the trail connecting Hilo town with the crater of Kilauea, island of Hawaii, in a spot corresponding to the present 22-mile point of the volcano road. Making of "kapa" (native cloth) out of "mamake" bark (*Pipturus albidus*), of olona fiber for fishing nets out of *Touchardia latifolia*, and capturing "O-U" birds for the sake of the few precious yellow feathers under the wings, of which luxurious royal garments were manufactured—those were the industries on which they lived.

For the reasons common to all the native

population of the islands, viz., the introduction of new germs of disease—syphilis, leprosy, tuberculosis, smallpox, etc.—this settlement gradually dwindled away, and in 1862 the few surviving members migrated to other localities. At present only patches of wild bananas, taro, and heaps of stones scattered in the forest indicate the places of former habitation and industry. I have heard, however, that as late as the seventies Kalakaua still levied a tax in olona fiber from the natives of Puna and Olona districts, which fiber he sold at high prices to Swiss Alpine clubs, who valued it for its light weight and great strength.

*Touchardia* grows abundantly in Olona forests, presenting a kind of a natural plantation. It very successfully holds its own in competition with ferns and other elements of the undergrowth in the shade of "ohia" trees (*Metrosideros polymorpha*). The deep shade, very porous soil, considerable moisture, with a yearly rainfall of 180 inches pretty evenly distributed, are the natural conditions. By removing some of the undergrowth, scattering seed, and probably by planting cuttings, the number of plants on the same area could be greatly increased with but very small expense. Since plants of medium age (about 18 months old) supply the best fiber, natives in gathering used to turn down the older ones with the foot, laying the whole plant on the ground to force new shoots and sprouts.

I was familiar with the plant and its properties for years, but did not pay any further attention to it as a possible object of industry for the reason that to all appearances the same difficulties in mechanical extraction of fiber will be met as in the case of ramie, for which no satisfactory machine has been found. Recently my interest in the matter was again aroused by Mr. Jared G. Smith, of the Hawaii Experiment Station. Considering that *Touchardia* seems to be free from resinous matter, upon his suggestion I decided to examine the subject more in detail. For this purpose an old native, born and raised in the settlement above mentioned, was interviewed. Together with him I proceeded into the forest along twenty-two miles side trail. In my presence



he picked the plants, stripped them of the bark, and with his own olden tools manufactured the sample of fiber.

My object was to ascertain what kind of plants he selects, and to see the primitive method of manufacture, with the idea that this method might furnish some suggestions for the construction of the machine. We had hardly made a dozen steps in the woods along the twenty-two-mile trail when a rich harvest of *Touchardia* was found. We found both male and female plants that could be distinguished only by inflorescence. Whereas male flowers are situated on relatively strong, repeatedly forking cymes, growing out of the base of the leaves, female ones look like so many flattened lumps of green dough planted at the base of the top branches. Both plants are taken indiscriminately. Careful discrimination is made, however, in regard to the age of the plant; neither too young nor too old ones are taken. The bark of the old ones is somewhat knotty, woody, and short jointed, and, as I have mentioned, such plant is turned down to the ground to force it to give new shoots. The best stems are not thicker than the finger, about one year and a half old, with the bark of a chocolate-brown color, with distanced scars of former leaves, straight and high (8 to 10 feet), devoid of leaves except on the top. Such stems are cut with the knife near the root and below the crown. Their bark strips easily as a whole from bottom to the top. The ribbon obtained is hung over the neck of the gatherers. There is also a plant with the leaves very much like those of *Touchardia*, the "hopue"; but this one generally grows to a large-sized tree, has different flower, and light-grayish color of the bark. Neither previous soaking nor drying are resorted to before the extraction. The bark is used raw.

The implements used are: (1) A wood board made of "naou" tree, characterized by its dark color, hardness, compactness, evenness, and absence of knots. This board is about 6 feet long by 2 to 3 inches wide. It has a very light curve in both directions—in width and length; is wider at one end and obtusely

pointed at the other. (2) A plate of fish bone of "honu" fish, about 8 inches long by  $2\frac{1}{2}$  wide, and is also slightly curved in both directions. Its lower margin is sharpened under  $45^\circ$  like the edge of a chisel.

The process of manufacturing is as follows: The "naou" board is fastened on the ground with rocks at the narrow end to prevent any forward sliding, the curved surface uppermost. The broader end is a little elevated by another piece of rock. The board is moistened with water. A ribbon of bark from one plant is taken. Its bottom end is first fastened by treading on it with the toe of the right foot, the top end raised vertically by the left hand, so as to tightly stretch the band. Holding the fish plate by the right hand in its middle, the sharp end of the bone is passed upward along the inner surface of the ribbon, which operation is intended for flattening the curled ribbon and taking off the slimy substance covering the inner surface. Then the ribbon is stretched horizontally upon the naou board, the bottom end toward the wider end of the board and the operator, and held tightly to it by the two fingers of the left hand, the outer surface of the bark upward, the inner sticking to the board. Then the fish plate, held in the right hand by the middle at  $45^\circ$ , with its sharp end downward and forward, squeezing the ribbon between the tool and the board, is repeatedly passed toward the pointed end of the board, by which motion the flesh is scrapped off, leaving a ribbon of fiber. From one to two minutes are required to free the bark of one plant. The operation of scraping is easy, the fiber evidently being located on the inner surface. The fiber thus obtained is dried in the sun.

Besides manufacturing fishing nets, natives used to make of it the best of their fishing lines. I am told that whalers in former times paid high prices for olona for making lines for whales. There is an old native in Hilo who still uses the line that was made and used by his grandfather.

VAUGHAN MACCAUGHEY

COLLEGE OF HAWAII,  
HONOLULU

**FRANK SLATER DAGGETT**

UNDER the directorship of Frank S. Daggett, the Museum of History, Science and Art of Los Angeles, has come to exert an important influence in science and education in Southern California. The collections representing the history of California and the southwest, and especially the splendid representation of the extinct life of California secured from the asphalt deposits of Rancho La Brea, have made the institution the object of frequent visits by large numbers of residents of California and by travellers from the east. The rapid development of the museum, the excellent organization of its collections, and the maintenance of a high standard of efficiency throughout the institution were in a very large measure due to the untiring effort of Mr. Daggett. Interesting and valuable exhibits representing living birds, mammals, and molluscs of Southern California were assembled under Mr. Daggett's direction, but by far the most important collection was that representing the extinct fauna secured in the extraordinary asphalt deposits at Rancho La Brea on the western border of the city.

Born at Norwalk, Ohio, in January 30, 1855, Mr. Daggett was for the greater part of his life engaged in commercial pursuits. He was a successful grain merchant at Duluth, Minnesota, from 1885 to 1894, and was a member of the Board of Trade of Chicago from 1904 to 1911. He was always deeply interested in natural history and from his early boyhood was engaged in the study of insects and birds.

His collection of Coleoptera numbered two thousand species and his bird collections contained over eight thousand specimens. Although he published little of a technical nature his interest in natural history subjects was a continued inspiration to many who were professionally engaged in scientific pursuits, and his influence in the advance of natural history of the Pacific Coast has been a factor of much importance.

Mr. Daggett became the director of the Museum of History, Science and Art in 1911. At the time of his assuming the office, the

building was finished, but contained no exhibits and no staff appointments had been made. Among the first tasks taken up was the securing of privileges for collecting in the Pleistocene deposits at Rancho La Brea. The excavations were carried on with the most extreme care and with all advice that could be obtained from those especially interested in the scientific study of the deposits. With the utmost precautions the great series of specimens unearthed was cleaned, prepared for study, and marked as to location in the beds. At no stage in the handling of this great collection was anything omitted which might have helped to make the material more useful to the student of future years. Along with its many other contributions to science the Rancho La Brea collection of the Museum of History, Science and Art must always remain as a monument to the scientific interest and administrative skill of Mr. Daggett.

It was the writer's privilege to make the acquaintance of Mr. Daggett at the time of his first interest in the deposits at Rancho La Brea, and to cooperate with him through the whole work of the excavation and preparation of these collections. In these years of close cooperation and friendship he proved himself a man of the highest ideals and finest purposes in development of all that is most fundamental and significant in the phases of natural science with which he came in contact. Although Mr. Daggett's name will not be known in future years by length of publication lists or by species described, there must be given to him a full measure for very significant constructive work done with much interest, with keen insight, and with an effectiveness which is rarely equalled.

JOHN C. MERRIAM

**JOHN LOSSEN PRICER**

JOHN LOSSEN PRICER,<sup>1</sup> of the Illinois State Normal University at Normal, Illinois, died suddenly of heart trouble on August 19, 1920. By his death the scientific interests of Illinois and other mid-western states have suffered a

<sup>1</sup> Born January 10, 1871. A.B. and A.M., University of Illinois, 1907.



very real loss. Professor Pricer had for years maintained an intimate and influential relationship to the problems involved in the teaching of the natural sciences in the secondary schools. His wholesome and extensive personal contact with science teachers and his untiring labor in the work of various educational organizations had brought him into prominence as one of the leaders in the program of reconstruction of the science curriculum of the secondary schools of the middle west. Unusual thoroughness of analysis, fairness of judgment, and whole-hearted sincerity had created for him a place in the esteem of his coworkers in natural science.

As secretary of the Illinois State Academy of Science for a period of four years, his service to that organization has been very marked. In this capacity as well as in his other relations he has done much to bring before the public the needs for more extensive education in science as a foundation for rational living and as an aid to the advancement of public health work.

The reception accorded his work upon the Life History of the Carpenter Ant<sup>2</sup> indicates his ability in original investigation. Teaching duties and a sense of personal obligation to devote his energies to teaching problems marked for him a course that lay chiefly through the educational field though he never lost interest in following the progress of current investigations.

H. J. VAN CLEAVE

### SCIENTIFIC EVENTS

#### THE ERUPTION OF KATLA IN ICELAND

THE volcano of Katla, situated some 50 kilometers southwest of Hekla, was in violent eruption in October, 1918, after remaining quiescent since the last previous eruption in 1860. A note by M. A. Lacroix in the *Comptes Rendus* of the Paris Academy of Sciences, abstracted in the *Geographical Journal*, gives some account of the eruption from data sent to him from Iceland. A little after noon on the 12th a slight earthquake shock was followed by the uprising above the

<sup>2</sup> *Biological Bulletin*, Vol. 14 (1908).

Mýrdalsjökull of an enormous column of incandescent ashes visible throughout the island for 200 to 300 kilometers. At Reykjavik a thick fall of ash darkened the whole sky, and a tidal wave was experienced on the coast south of the volcano. As is usual in Iceland, the paroxysm was accompanied by violent glacier outbursts. The first visitor to the crater after the eruption was M. Pall Sveinsson, whose notes have been placed at M. Lacroix's disposal. Katla lies in the east-southeast of the Mýrdalsjökull, one of the great ice-masses of southern Iceland, and on its southeast side extends the Mýrdalsandur, a great desert of sand formed of the material deposited during the glacial outbursts. In the northwest and southwest the Mýrdalsjökull is surmounted by two domes of ice rising to heights of 1,500 to 1,600 meters. Between them is a cup-shaped depression at the bottom of which the crater of Katla opens. Even the outer slopes of the ice-dome by which M. Sveinsson ascended were covered with ashes to a depth of half a meter, and those falling to the crater with half as much again. The rift of the crater, which measured from 500 to 800 by 40 meters, was free from ice, but water was flowing along it. No fumeroles nor products of sublimation were seen, only a yellowish-brown mud, the lighter portions of which seem derived by alteration from the darker, heavier ash. The glacier torrents had opened two deep ravines towards the south and east, and had done considerable damage, carrying with them huge masses of ice to a distance of 30 kilometers. The stony débris had formed a vast promontory on the coast similar to that formed in 1860. Like the thirteen previously recorded eruptions, that of 1918 was exclusively explosive, with no outpouring of lava—a fact more remarkable from the vicinity of Katla to the scene of the great fissure eruption of 1783. A chemical comparison of the ash of 1918 with the lava of 1783 will be of interest, for it is possible that the exclusive explosive character of the Katla eruptions may be due to the superimposition of the enormous ice-mass of the Mýrdalsjökull. A preliminary

analysis of the ash shows it to be rich in titanium, a character common to the few examples yet analyzed of the basaltic volcanic rocks of Iceland, the Færoes, and Greenland.

#### UTILIZATION OF THE FORESTS OF ALASKA

COLONEL W. B. GREELEY, the new chief forester of the United States, has returned from a month's inspection of the timber, water power and national resources of Alaska. In an interview in the *Seattle Post-Intelligencer* he is reported to have said:

Alaska has more than 100,000,000 cords of pulp wood. The territory has sufficient timber resources to produce 1,500,000 tons of paper annually. The Alaska Pulp and Paper Company, comprising California interests, is now constructing the first pulp plant at Port Snettisham, in southeastern Alaska. This mill will be supplied with 100,000,000 feet of timber just purchased from the Forest Service and is probably the forerunner of a large pulp and newspaper factory at that point.

In addition to the vast pulp resources of Alaska, Puget Sound offers splendid opportunity for at least six large pulp and paper mills. There are frequent inquiries of the Federal Forest Department for pulp wood concessions in this state. Even at the present time there is enough or would be enough wood of inferior quality cut in logging camps to support a large local paper industry here.

Establishment of such an industry on Puget Sound would be a great accomplishment from the standpoint of practical conservation—it would afford a market for inferior woods now being wasted in logging camps already established. In addition, there are large areas of hemlock and spruce and balsam on the Olympic Peninsula and in the Snoqualmie national forest. The entire forestry industry of the United States is moving westward, and with it is coming the paper industry.

Alaska contains 100,000,000 cords of pulpwood. She has the resources to produce 1,500,000 tons of paper yearly. That is nearly a third of the paper used in the United States, an amount nearly equal to what we are now compelled to import from Canada. With reasonable care, under the methods followed by the Forest Service, this output can be kept up from the national forests of Alaska perpetually. There is a real solution of the paper shortage.

A few years ago we heard much about the inferior character of the forests in Alaska. As a matter of fact, aside from enormous quantities of good pulpwood and serviceable construction timber, the territory probably contains the largest quantity of clear, high-grade spruce to be found in the United States.

During the war this spruce passed every test for airplane construction, and it is now being shipped to the eastern states in increasing quantities for car and factory stock and high-grade finish. One of the things we shall accomplish by bringing the paper industry into Alaska will be to open up her thousands of miles of coastal forests and make available a much larger supply of special products like cedar, clear spruce and long piling.

#### THE INTERNATIONAL CHEMICAL CONFERENCE

THE third session of the International Chemical Conference met at Rome, June 21 to 25, with Professor Charles Moureu, member of the Institute of France, as president. According to the account of the *Journal of Industrial and Engineering Chemistry* the program began with the meeting of the council of the International Union of Pure and Applied Chemistry, composed of the representatives of the five nations which founded the Union. The council considered the adhesion to the union of seven new countries: namely, Canada, Denmark, Spain, Greece, the Netherlands, Portugal and Czecho-Slovakia, which were all admitted. The plan of organization and administration of the International Union of Pure and Applied Chemistry, which was presented by M. Gerard, was as follows:

To adhere to the union a country must establish a liaison between its chemical groups by the formation of a national council or federation. The initiative of this organization must be taken by a chemical society, the National Academy, the National Research Council or a similar national institution, or by the government.

The union is governed by the council, composed of delegates from each of the supporting countries, whose executive power is vested in a bureau. The general assembly receives reports from the council, approves the accounts of the past session, adopts the budget for the following session, and considers the questions to be included on the program. Under the council and an executive com-



mittee, a permanent staff carries out the program of action as defined by the bureau. This staff is situated at the headquarters of the union, and is the pivot of all the organizations connected therewith. The council can also establish permanent committees as they may seem necessary.

An advisory committee, divided into sections corresponding to the different scientific and industrial branches, considers in detail the questions figuring in the program of action. The associated nations are represented in each section by delegates, elected for three years. The delegates of each nation constitute a national committee, whose duties include the study of questions interesting to chemistry from scientific, industrial, and economic points of view.

A meeting of the council, of the permanent committees, of the advisory committee, and of the General Assembly is held each year, under the title of the "International Chemical Conference."

The report presented by Professor Lindet, for the *Fédération Nationale des Associations de Chimie de France*, asking that the International Congress be joined to the union, provides that the International Conference shall every four years be converted into an International Congress of Pure and Applied Chemistry. Elections to the council, to permanent committees, and to the advisory committee shall take place at this time.

The languages for the congress are English, French and Italian. Communications may be made in another language, provided authors give a translation or an abstract in the official languages. To avoid errors in interpretation, communications, votes, resolutions, and official acts, if not originally offered in French, must be translated into that tongue.

To encourage research, the council may, within the limit of funds granted each year by the assembly, award prizes and medals to the authors of work considered worthy of such distinction.

#### MISSOURI EXPERIMENT STATION OF THE BUREAU OF MINES

SECRETARY OF THE INTERIOR PAYNE, acting on the recommendations of Dr. F. G. Cottrell, director of the Bureau of Mines, has selected Rolla, Mo., as the place for the latest mining experiment station of the bureau. This station will look after the mining interests of the Mississippi Valley and will give consideration to the various problems which are met with in the production of lead and zinc.

After a careful investigation, The Missouri School of Mines and Metallurgy at Rolla, Mo., was selected as an ideal place to carry on much of the actual laboratory and investigative work of the new station. However, it was also decided that the central offices of the station should be at or near St. Louis, Missouri. Consequently, the plan is that the actual laboratory and investigative work shall be done in cooperation with the Missouri School of Mines and Metallurgy at Rolla, but that headquarters of the station should be in St. Louis.

For a long time the Bureau of Mines has desired to take up, in cooperation with the mining and metallurgical industry, those problems met with in the Mississippi Valley where lead and zinc deposits occur. As is well known, the ores of this district are for the most part sulphide ores and are ordinarily not difficult to treat. However, there are also large deposits of oxidized lead ores in certain districts of Missouri, and their mining and metallurgical treatment presents a serious problem. Concentration by gravity methods had been tried for years on these ores, and there are many thousands of tons of high grade tailings, as well as crude ore, awaiting proper methods of recovering metallic values. Such being the case, the bureau will carry on such research and investigational work in connection with the treatment of these ores as will assist in the development of processes which will prevent their being wasted, due to the lack of a metallurgical process which it may be commercially feasible to apply to them.

#### SCIENTIFIC NOTES AND NEWS

PROFESSOR R. ROUX, director of the Pasteur Institute at Paris, has been awarded by the United States government the Distinguished Service Medal for especially meritorious and distinguished service which was of great consequence to the American Expeditionary Forces.

A PRESENTATION from more than two hundred subscribers has been made to Dr. W. L. H. Duckworth, fellow of Jesus College and senior demonstrator in anatomy, in the Uni-

versity of Cambridge, on the completion of twenty-one years of service to the university as lecturer in physical anthropology.

DR. NOEL BARDSWELL, medical adviser to the London Insurance Committee, has been awarded the Médaille de la Reconnaissance Française for services rendered in Paris in connection with the treatment of the tuberculous French soldier and the establishment of an agricultural training colony at Epinay.

THE Dr. Jessie Macgregor prize of the Royal College of Physicians, Edinburgh, has been awarded to Miss Lucy Davis Cripps for her work on tetryl.

A DINNER was given July 26 by the president, vice-president and governors of the American Hospital in London to Dr. Charles H. Mayo, of Rochester, Minn.

H. L. HARNED has been appointed consulting chemist and R. L. Sebastian, research industrial chemist, to the Pennsylvania State Department of Health Laboratories.

DR. W. C. PHALEN, formerly geologist in the U. S. Geological Survey and mining technologist in the Bureau of Mines, has been engaged as geologist by the Solvay Process Co., with headquarters at Syracuse, N. Y.

MR. LEWIS DAVIS, formerly biological chemist in the research laboratory of Parke, Davis & Company, Detroit, Mich., is now associated with the Beebe Laboratories, Inc., St. Paul, Minn., as associate laboratory director.

O. B. WHIPPLE, professor of horticulture in Montana College has resigned to engage in farming in Colorado.

LIEUTENANT COLONEL HARRY PLOTZ, M.C., U. S. Army, has returned from Europe after spending several months in investigating the spread of typhus fever in infested regions. Typhus fever is raging in Poland, Southern Russia and Eastern Europe.

DR. LIVINGSTON FARRAND, chairman of the American Red Cross, formerly president of the University of Colorado and professor of anthropology in Columbia University, has gone to Europe.

THE Ramsay Memorial Executive Committee has decided to close the general fund.

The total amount received up to date is £53,402, this sum being exclusive of the fellowships founded by the Dominion and foreign governments, the capital value of which is estimated at about £30,000. Although the general fund is closed, contributions sent in to the treasurers, Lord Glenconner and Professor J. Norman Collie, at University College, London, can still be included in the complete list of subscriptions which is now being prepared. The Ramsay Memorial Fellowship trustees have elected Mr. William Davies, M.Sc. (Manchester), at present working in the chemistry laboratories of the University of Oxford, to a Ramsay Memorial Fellowship. This election is the first election to a fellowship provided from the Ramsay general fund.

It is proposed to establish in Panama an international institute for research on tropical diseases as a memorial to the late Major-General William C. Gorgas. Panama has been chosen in view of the fact that General Gorgas' most noteworthy work was accomplished there.

JAMES WILSON, secretary of agriculture in the cabinets of Presidents McKinley, Roosevelt and Taft, previously professor of agriculture in the Iowa State College and director of the Experiment Station, died on August 26, at the age of eighty-five years.

BENJAMIN SMITH LYMAN, geologist and mining engineer of Philadelphia, died on August 30, in his eighty-fifth year. Mr. Lyman, who graduated from Harvard in 1855, had traveled extensively in the United States, British America, Europe, India, China, Japan and the Philippines in connection with his geological researches. In 1870 he was employed by the Public Works Department of India, surveying oil fields. From 1873 to 1879 he was chief geologist and mining engineer for the Japanese government. From 1887 to 1895 he was assistant geologist of the state of Pennsylvania.

WILHELM WUNDT, professor of philosophy at the University of Leipzig, where he established the first laboratory of psychology, died on August 31, in his eighty-ninth year.



ADAM POLITZER, professor of otology at Vienna, has died at the age of eighty-six years.

*Nature* states that one of the first official acts of the new high commissioner of Palestine has been the establishment of a Department of Antiquities. An international board will advise the director on technical matters. Provision is made for an inspector, for a museum, and for the custody of the historical monuments. The museum starts with more than 100 cases of antiquities collected by the Palestine Exploration Fund and other bodies before the war. On August 9 the new British School of Archeology was formally opened at Jerusalem by Sir Herbert Samuel.

THE Pennsylvania State College has received from the Rockefeller Institute for Medical Research a grant of \$5,000 for the current fiscal year in aid of the researches in animal nutrition which have been carried on for the past twenty years by the Institute of Animal Nutrition under the direction of Dr. H. P. Armsby.

THE autumn meeting of the British Institute of Metals will be held at Barrow-Furness on September 15 and 16, under the presidency of Sir George Goodwin.

IN the second week of September there is to be a gathering at the School of Anthropology at Paris of a number of persons interested in forming an International Anthropological Institute and in making it the center for the anthropologic sciences, including ethnology, eugenics, medical geography, comparative anatomy, etc.

THERE has been organized the Mexican Society of Biology which for the time being will hold its meetings at the headquarters of the National Academy of Medicine. The officers of the association are: *President*, Dr. D. Fernando Ocaranza; *Treasurer*, Dr. Eliseo Ramírez, and *Secretary*, Dr. Isaac Ocheterena. The society has ten charter members, practically all physicians. The address is Av. del Brasil, No. 33, Mexico.

THE chief executive officers and large stockholders of the General Chemical Company, the Solvay Process Company, the Sement-Solvay

Company, the Barrett Company and the National Aniline & Chemical Company, have approved a general plan for submission to the respective boards, for the consolidation of the five companies.

WE learn from *Nature* that at the council meeting of the National Association of Industrial Chemists, held at Sheffield on August 7, the secretary reported that a number of firms had given a definite undertaking to consult the officials of the association in all matters relating to chemists, their appointment, salaries, and conditions of employment. The salaries paid to members of the association were fairly satisfactory; in this connection a report has been issued giving a schedule of minimum salaries, and this would be circulated shortly. The secretary stated that the number of unemployed chemists was increasing rapidly, and there was every indication of a coming great slump in the engineering and allied industries in which their members were employed. It was more than ever imperative for industrial chemists to unite to preserve their interests. Mr. A. B. Searle (Sheffield) was unanimously elected president for the coming year, and Mr. J. W. Merchant appointed secretary. The appointment of an organizing secretary for propaganda work was authorized.

#### UNIVERSITY AND EDUCATIONAL NEWS

By the will of the late William K. Vanderbilt, Vanderbilt University receives \$250,000.

By the will of the late Miss Annette P. Rogers, daughter of the first president of Massachusetts Institute of Technology, Radcliffe College receives \$175,000.

Two research fellowships of \$1,200 each have been established at Rutgers College by Dr. J. G. Lipman, dean of agriculture and director of the experiment station at that institution. The appointees to the fellowships will study problems relating to the place and functions of sulfur in the plant world.

DR. CALVIN C. APPLEWHITE, U. S. Public Health Service, has been detailed to establish

a school of public health and hygiene in the medical department of the University of Georgia, Augusta.

DR. ARTHUR S. HATHAWAY, since 1891 professor of mathematics at the Rose Polytechnic Institute, has retired from active service. He is succeeded by Dr. I. P. Sousley, of Pennsylvania State College.

PROFESSOR FREDERICK SLOCUM has returned to Wesleyan University as professor of astronomy and director of the Van Vleck Observatory.

MR. GUY R. MCDOLE, assistant soils chemist in the Minnesota Agricultural Experiment Station, has accepted a position as associate professor of agronomy and soil technologist at the University of Idaho.

DR. ROBERT STEWART, who has for the past five years been associated with the late Dr. Cyril G. Hopkins at the University of Illinois as professor of soil fertility, has resigned his position to accept the deanship of the college of agriculture of the University of Nevada.

DR. ARTHUR T. EVANS has accepted the position as associate agronomist in South Dakota State College and Experiment Station. He has previously been professor of botany and dean at Huron College; and earlier engaged in corn disease investigations with the Cereal Office of the United States Department of Agriculture.

DR. WM. CONGER MORGAN has resigned his position as professor of chemistry at Reed College to become professor of chemistry at the Southern Branch of the University of California at Los Angeles.

C. LEE SHILLIDAY, professor of anatomy and histology in the college of dentistry, University of Tennessee, has accepted the professorship of biology in the Pennsylvania College of Gettysburg, to succeed Dr. George Stahley, who has retired after thirty years' service.

ASSOCIATE PROFESSOR BURT P. KIRKLAND, and Assistant Professor E. T. Clark, of the college of forestry and lumbering of the University of Washington, have been promoted, the former to a full professorship and the latter to an associate professorship.

DR. WILLIAM BOYD, professor of pathology in the University of Manitoba, Winnipeg, has declined the offer of the chair of pathology at the medical school, Cairo, Egypt.

DR. FRIEDMANN, the value of whose turtle vaccine for tuberculosis is questioned, has been appointed extraordinary professor at the University of Berlin against the vote of the medical faculty.

DR. A. GOSSET, professor of external pathology of the Paris medical faculty, has been appointed to the chair of clinical surgery left vacant by the retirement of Professor Quénu, and Dr. Vaquez, professor of internal pathology, has been appointed to succeed Professor Robin in the chair of clinical therapeutics.

## DISCUSSION AND CORRESPONDENCE

### A BAND SPECTRUM FROM MERCURY VAPOR

TO THE EDITOR OF SCIENCE: The writer has recently observed that under certain conditions the discharge through mercury vapor gives a glow that is distinctly green. An examination of this glow shows the ordinary line spectrum of mercury together with a spectrum which is apparently continuous through nearly all of the visible spectrum, being most prominent in the green. So far as the writer has been able to learn there is no record of such a spectrum having been obtained from the discharge through mercury vapor.

Two conditions are necessary for obtaining this spectrum with any considerable brightness. First the vapor through which the discharge takes place must be passing from a hotter to a colder region, as from the mercury arc or from the mercury heated by a flame to a condensing chamber, that is, through vapor that is condensing.

Secondly the voltage must be kept as low as possible and yet have a discharge. As the voltage is raised the ordinary line spectrum becomes more prominent and the continuous spectrum less so. The discharge from a Wimhurst machine or from a transformer shows the glow somewhat better than that from an induction coil. Putting condensers in parallel



with the spark has the same effect as increasing the current. It is possible to obtain the glow from hot calcium oxide providing the discharge is kept very small.

The shape and position of the electrodes have no appreciable influence on the production of this glow. It is produced equally well from platinum and from iron electrodes and in tubes made from soda and from lead glass. It does not appear to depend on the purity of the mercury.

It requires approximately .001 sec. for the glow to die out after the exciting current has ceased. As a result of this continuance of the glow the radiators may continue to give light while being carried with the current of mercury vapor for 20 or 30 cm.

These radiators do not appear to be charged. Thus if the luminous vapor containing them is passed through wire gauze, no effect is produced on the intensity of the continuous spectrum when the gauze is charged negatively. This is quite different from the behavior of the radiators of the line spectrum which may be entirely removed by this means. It is possible in this way to obtain the continuous spectrum without any of the line spectrum appearing.

As far as has been observed there are no lines or separate bands in the spectrum here described. It is, however, possible that a spectroscope better than the one at the command of the writer may show such lines.

It appears probable that we are here dealing with a vapor which is intermediate between a gas and a liquid. When a gas is condensing there must be a time when two or more atoms have combined to form clusters. Such a vapor might be expected to give a spectrum intermediate between a line spectrum as given by a gas and a continuous spectrum as given by a liquid or solid. This is a fact the kind of spectrum here observed.

Further work is being done on the subject and it is expected that the results will soon be published in more complete form.

C. D. CHILD

COLGATE UNIVERSITY,  
August 6, 1920

#### A NEW VARIETY OF THE ROOF RAT

DURING the second week of March of this year Miss Jane F. Hill, one of our students, brought to the laboratory about a dozen rats, which had been taken on her father's farm. The farm is located fifteen miles from Austin, in Travis County, Texas. Seven of these rats were cinnamon in color, the others, obviously the wild type, were gray or brownish. The cinnamon color is restricted to the back and sides of the head and body, and is due to the presence of yellow pigment in the outer ends of the hairs, the pigment of the hair base probably being chocolate. In the type and mutant specimens the fur on the ventral surface, from the chin to the base of the tail, is snow white, the hairs being white from the tip to the base.

We attempted to keep these rats in the laboratory, but after a few weeks they began to die. I then instructed one of our assistants to preserve the skins. Some of these were later sent to Professor W. E. Castle, who showed them to Dr. G. M. Allen. Dr. Allen identifies the species as the roof rat, *Mus alexandrinus*.

We were anxious to establish a stock of the cinnamon rat for genetic studies, and through the kindness of Miss Hill and her family, I was able to visit the farm on July 6. During the day we captured 215 rats. Upon examination, the rats proved to be of three varieties, *Mus norvegicus*, *Mus alexandrinus*, and the cinnamon mutant. We took 61 specimens of the common Norway, 138 of the type of roof rat, and 16 of the cinnamon. Undoubtedly some of the 138 specimens of the roof rat are heterozygotes. We were fortunate enough to capture a mother and four young in one nest. Three of the litter are like the brownish-gray mother, and the third a typical cinnamon.

The interesting point concerning the discovery of this cinnamon rat relates to its origin. When and how did it happen to appear on the Hill farm? With a view of answering these questions, I made a careful study of the conditions on the farm. The farm buildings where the rats are found are close together and

are fairly well isolated. With the exception of one neighboring place, located about 400 yards from the Hill buildings, all other neighbors are at least a half mile distant. The cinnamon rats had not been observed prior to last Christmas, when Miss Hill saw a single animal in the grain house. From time to time others were seen in increasing numbers about the place.

The rats in the farm buildings have reached such numbers that they have become very destructive. This coupled with the fact that bubonic plague has appeared in Texas, made it necessary to attempt their extermination. During the past few weeks over 1,000 rats have been killed, and among these were found a number of the cinnamon variety. From the best available data, I estimate that at present the proportion of cinnamon specimens to all others is about 15 to 200.

The cinnamon rat has not been observed at any of the neighboring places, with the exception of the one located 400 yards away, where two animals were recently seen. All of the evidence points to the conclusion that this new variety arose, possibly as a mutation from *Mus alexandrinus*, on the Hill farm some time during the latter part of last year.

This rat should furnish an opportunity for some interesting genetic studies. In a recent letter Professor Castle has called attention to the value of this material. He says:

This would be very interesting genetic material for there is known to be a yellow variety of the roof rat, in addition to the black variety (*Mus rattus*), and if this cinnamon variety can be added to the number (with albinism, which I presume must exist among roof rats), it would be possible to work out from this material a parallel series to that which occurs in the Norway rat, possibly even a more complex series, and it would be of interest to know whether the linkage relations are the same in the two species.

J. T. PATTERSON

AUSTIN, TEXAS,  
July 22, 1920

#### ANOTHER CORN SEED PARASITE

A FUNGUS which seems to have had very little consideration as a parasite has recently

been isolated from sweet corn seed by the writers while making a study of the internal parasites of some agricultural seeds.

This fungus was frequently found in corn from a field that last year had many dwarf and distorted stalks and some barren stalks and root rot. Seeds of this corn were examined for internal parasites by treating three minutes with corrosive sublimate solution according to a method which the authors have worked out and found to be very satisfactory. After this external disinfection they were planted in sterile tubes of nutrient solution on cotton. In about a week a white fungus had grown out from many of the seeds, some of which had also germinated. The roots of the seedlings were attacked by the fungus and died in about two weeks. Healthy seedlings in sterile tubes were inoculated and died in five to nine days.

The pathogenicity of the fungus was further tested under more normal conditions on corn grown in pots in the greenhouse, by pouring a suspension of the spores from pure cultures around the roots and by punctures with an infected needle just above the ground. Several of the plants so infected showed the dwarfness and distortion seen in the field the previous year. Those inoculated by puncture made 19 per cent. less growth in height than the controls and the soil inoculations made 13 per cent. less. Fungous mycelium was found in the discolored tissue at the base of the stem of these infected plants and the original fungus was obtained in cultures from this diseased tissue.

This fungus corresponds very well, so far as one of its methods of spore formation is concerned, with descriptions and figures of *Oospora verticilloides* Sacc., found on corn in Italy by Saccardo in 1877. It was extensively studied by Tiraboschi<sup>1</sup> in an investigation of organisms in corn that might be connected with pellagra. Tiraboschi, like practically all other students of corn diseases, apparently overlooked similar work done in Russia in 1895 and 1896 by Deckenbach, who in addi-

<sup>1</sup> *Annali di Botanici*, 1905.



tion found that *Oospora verticilloides* was parasitic on corn. Deckenbach's work was published in Russian journals from 1896 to 1899, and after Tiraboschi's paper was published, Deckenbach reviewed his original work in *Centr. Bakt.*, 1 Abt. Originale, 45:507-512. 1907.

It is probable that this fungus has been recorded under other generic names by some writers. *Cephalosporium sacchari*, described by Butler as a sugar cane parasite in India, accords very well with our fungus, except that the conidia in chains were not noted by him. The distinctions between *Cephalosporium*, *Acrostalagmus*, *Verticillium* and similar genera are slight, and as the chains of spores of our fungus are not always easily found, this corn parasite may sometimes have been classed in one of these genera. The writers find, however, that the conidia are produced in two different ways: at first they are aggregated in small droplets at the ends of the short, sometimes verticillate, lateral branches of the erect fertile hyphæ, and later produced in long chains on the ends of the upper branches. In older cultures septate spores are occasionally found and if a *Fusarium* stage should develop our fungus would have to be referred to Sheldon's *Fusarium moniliforme* which would then better be called *Fusarium verticilloides*.

J. B. S. NORTON,  
C. C. CHEN

MARYLAND AGRICULTURAL EXPERIMENT  
STATION

### SCIENTIFIC BOOKS

*Orthoptera of Northeastern America with Special Reference to the Faunas of Indiana and Florida.* By W. S. BLATCHLEY. May, 1920. Indianapolis: The Nature Publishing Co.; 8vo, 784 pages, 246 text figures and 7 plates.

This work comprises a very full consideration of the 353 species and 58 varieties of Orthoptera recorded from the region covered, and is the most comprehensive treatise on this group of insects so far published in America. While prepared more especially for the tyro, this volume contains a wealth of

assembled information of undoubted value to professional workers. As clearly set forth on pages 5 to 7 of the introduction, this work portrays the individual ideas of the author as to the systematic value of taxonomic characters used in classification. The conclusions reached, while not always in accord with recent usage, appear to be generally sound.

The biology and anatomy of the Orthoptera are treated at some length and the parasites and other enemies of the group are discussed. Economic questions are covered and the collection and preservation of specimens fully treated. The systematic portion includes dichotomous keys to suborders, families, genera and species. The derivation of generic names is given when known and many species are figured. The illustrations are mostly taken from previously published works, but the figures are well selected for the purpose of the present manual. Under each species is a description followed by notes on synonymy, distribution, habits, etc. Citations to literature are made by reference to a chronologically arranged author's bibliography. A glossary of terms used is given and there are two indices, one of synonyms with generic assignment and one of genera and species as here treated.

There is in general little to criticize in this very admirable treatise, though a critical review written by any specialist would probably point out a number of details considered open to special criticism. As is inevitable with a volume of this size a number of typographical and other errors occur. But on the whole it is a carefully prepared work, and one which will be indispensable to all students and collectors of these insects.

A. N. CAUDELL

BUREAU OF ENTOMOLOGY,  
U. S. DEPT. OF AGRICULTURE

*Manual of the Orthoptera of New England, including Locusts, Grasshoppers, Crickets, and their allies.* By ALBERT P. MORSE. April, 1920. *Proc. Bost. Soc. Nat. Hist.*, Vol. XXXV., p. 197-556, text-figures 1-99 and plates X-XXIX.

Bearing a date a month earlier than the above work by Blatchley, but received nearly a month later, comes this volume, a magnificent treatise on the orthopterous insects of New England. An introduction to the literature of New England Orthoptera is given and the anatomy and biology of this group of insects are discussed at some length. The distribution of the species within the region covered is considered and there are several pages devoted to a consideration of the economic relations of the Order, including discussions of parasites and other enemies. Collecting and preserving are fully treated and there are keys to genera and species and higher groups. Under each family are notes on habits, etc., and under each species are references to the more important literature on the species and its synonyms. There are also notes on occurrence and, usually, brief descriptions. One hundred and thirty-two species are recorded, sixteen of which are considered adventive. There is no bibliography of works cited. The structural details of a large proportion of the forms treated are figured, and many are more fully illustrated, some in colors. There are also a number of reproduced photographs showing certain characteristic habitats of Orthoptera. Three colored plates and a few other illustrations are original, but most of the figures are reproduced from previously published works. An accented list of scientific names, a glossary, and an index conclude this most excellent manual.

A. N. CAUDELL

BUREAU OF ENTOMOLOGY,  
U. S. DEPT. OF AGRICULTURE

#### SPECIAL ARTICLES

##### A STAND FOR THE BARBOUR MICRODISSECTION APPARATUS

THE following is a description of a stand devised by the writer and Mr. F. H. J. Newton, mechanic at Wesleyan University, for use with the Barbour microdissection apparatus. The dissecting apparatus was also made by Mr. Newton, who reproduced with

slight modifications, in part suggested by Dr. Robert Chambers, the two-needle model formerly made in the Fowler shops of the University of Kansas.

The principal advantage of the stand as previously stated by Dr. Chambers<sup>1</sup> is that the dissecting apparatus is attached to a shelf independent of the microscope and consequently the latter may be shifted to various positions with reference to the dissecting apparatus. Also another microscope or binocular microscope may readily be substituted without the necessity of the assistance of a machinist to construct a shelf on each microscope used.

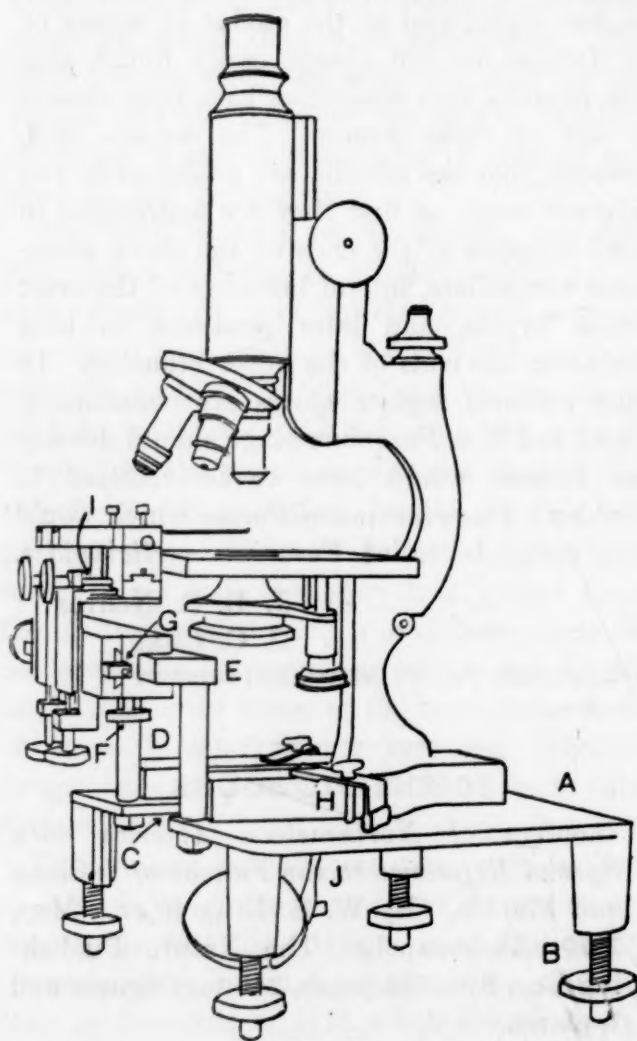


FIG. 1.

The drawing here shown omits for simplicity certain details of the dissecting apparatus as it has been figured elsewhere.<sup>1</sup> The thumb screw on the right side which is at

<sup>1</sup> Chambers, R., *Biological Bulletin*, Vol. 34, 1918.



tached at *G* is omitted from the drawing in order to show parts otherwise concealed.

The essential parts are the platform and shelf. The platform, *A*, which measures  $9\frac{1}{2}$  by 7 inches is supported on legs having leveling screws, *B*, and has a portion cut out, *C*, on the longer side similar in form to the open space between the sides of the horseshoe base of a microscope. This opening is to admit light from an ordinary microscope mirror suspended beneath the stand by a jointed arm, *J*, allowing lateral motion and which is in turn attached to a horizontal rod sliding back and forward in a tube on the under surface of the platform. On the front edge of the platform bridging the light opening is the shelf, *E*, supported by two pillars, *D*. The dissecting apparatus is clamped to this shelf by the screw, *F*. The microscope may be firmly secured to the platform by the clamps, *H*, and holes are drilled in the platform to accommodate various positions of the microscope, but frequently the use of the clamps is unnecessary.

Dr. Chambers has suggested that I call attention to a useful improvement of his own dissecting apparatus introduced by E. A. Thompson, of Amherst, Mass. Fine springs placed around the screws which move the needle carriage as at *I* in the figure prevent lost motion and thus steady the initial motion of the needle which is a marked advantage in the finer work.

H. B. GOODRICH

WESLEYAN UNIVERSITY

#### GASTRIC RESPONSE TO FOODS<sup>1</sup>

##### IX. THE INFLUENCE OF WORRY ON GASTRIC DIGESTION

THE study of the influence of emotional strain on digestion in man offers some difficulties due to the fact that the emotions can not be readily controlled, nor are the subjects of extreme emotion readily amenable to experimentation. We were, however, able to obtain an interesting illustration of the pro-

<sup>1</sup> The expenses of this investigation were defrayed by funds furnished by Mrs. M. H. Henderson.

found effect of mental anxiety on gastric digestion in the case of a first-year medical student who had previously served as a subject of gastric tests and whose stomach had been found entirely normal. This man was given one hundred grams of fried chicken on the morning of an important examination in chemistry, and was asked to write out his answers during the course of the test. He was plainly worried over the outcome of the examination and of his year's work. The resultant effect upon gastric digestion in prolonging evacuation for over two hours, with high intra-gastric acidity is charted in the figure. The same chart gives the normal

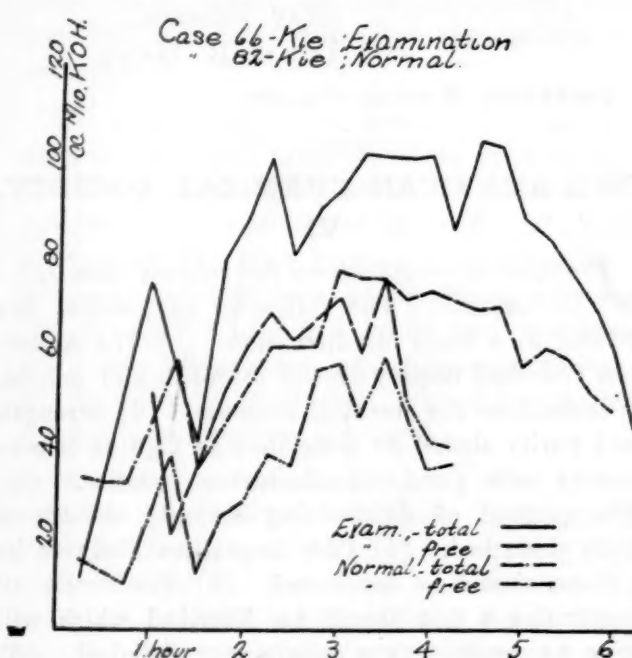


FIG. 1.

digestion curve for fried chicken on this subject as obtained a week later under the best mental conditions.

The experiments were carried out by withdrawing samples from the stomach of the subject with the Rehfuß stomach tube at fifteen-minute intervals until the stomach was empty. The specimens were analyzed for total acidity and free hydrochloric acid and results expressed as c.c. of N/10 alkali required to neutralize 100 c.c. of sample.<sup>2</sup>

<sup>2</sup> Fishback, Smith, Bergeim, Lichtenthaeler, Rehfuß and Hawk, *Am. Jour. Physiol.*, 1919, XLIX., 174, and later communications.

Pavlov, Cannon, Bickel and Sasaki<sup>3</sup> and others have shown that in animals fear and rage may exert a most pronounced inhibiting effect on gastric peristalsis and secretion. It is also known that the clinical symptoms of gastric ulcer may be aggravated by emotional excitement due apparently to delayed evacuation associated with the hypersecretion of gastric juice commonly found in such cases. Our experiment is a clear-cut demonstration of a purely emotional dyspepsia and may serve as an additional emphatic warning to us all not unnecessarily to carry our troubles with us to the dinner table.

RAYMOND J. MILLER,  
OLAF BERGEIM,  
PHILIP B. HAWK

JEFFERSON MEDICAL COLLEGE

## THE AMERICAN CHEMICAL SOCIETY. VI

*Problems in specifications for reagent chemicals:* W. D. COLLINS. The following suggestions are offered as a basis for discussion: (1) The American Chemical Society should establish and publish specifications for chemical reagents. (2) Strength and purity should be prescribed as high as is consistent with good manufacturing practise. (3) The method of determining strength should be fully described. (4) Only impurities likely to be present should be considered. (5) For nearly all impurities a test should be described which will give no result with a satisfactory chemical. (6) The specifications should contain no provisions for penalties or premiums for variations from the strength and purity prescribed. (7) The specifications should not in general demand the purity required for work of the very highest refinement. (8) Specifications for containers are not necessary. (9) Names of manufacturers or brands should not be used in the specifications.

*The standardization of laboratory apparatus and instruments in respect to quality, shape, size and packing:* THOMAS B. FREAS. The manufacture of

<sup>3</sup> Pavlov, "The Work of the Digestive Glands," London, 1902; Bickel and Sasaki, *Deutsch. med. Wochenschr.*, 1905, XXXI., 1289; Cannon, "Bodily Changes in Pain, Hunger, Fear and Rage," New York, 1920.

apparatus in this country is necessary in order to produce enough qualified skilled workers and experts to aid in times of national emergency. The cost of labor being high, the quantity basis of manufacture is urged. The splitting of endeavor is caused by the manufacture of too small quantities of any particular piece of apparatus. Quality, shapes and sizes of glassware, porcelain ware, rubber goods, woodenware, and platinum need standardizing. Possibly the number of shapes and sizes, at least, could be reduced to such an extent that the output per individual article would be materially increased. Reasons for packing in standard packages are also given and it is shown that this will tend to reduce overhead, especially in the dealer's business and allow a consequent reduction to the consumer. It is proposed to have a standardization office with a draftsman, the expenses of this office to be met by a small fee upon all the apparatus bearing the stamp of the committee of this society. If this small fee does not seem feasible, then some scheme should be adopted by which the Bureau of Standards would be able to carry out the ideas of standardization.

*Recovery of the grease from the soapy wash waters in laundering:* I. N. KUGELMASS. On the average a twenty-five gallon first suds waste yielded about one half liter of fatty acids extracted by gravitational separation through naphtha.

*A rapid soap dissolving-distributing system:* I. NEWTON KUGELMASS. The soap-dissolving tank contains a forty-five degree inclined perforated support suspended near the top of the tank, automatically fed with soap flakes and the whole immersed in water. An electric stirring device hastens solution. The clear soap solution is distributed to washers by pipe lines. At each washer a gauge gives the volume of soap solution passing through it into the washing machine. Advantages: rapid solution, economy in soap, time, and labor, correct soap concentration in washers.

*The recovery of iodine from kelp:* MERLE RANDALL. This paper is a summary of a study of the leach liquors at the U. S. Kelp-Potash Plant at Summerland, Calif. Green kelp, such as is harvested on the Pacific coast, contains about 0.0016 per cent. of iodine. The kelp is dried in direct heat driers, and charred either in incinerators or in retorts. The char is leached with hot water, and potassium chloride and sodium chloride removed from the leach liquor in crystallizing evaporators. Iodine should remain in the mother liquors. The



solutions contain sulfates, carbonates and reducing substances. A method for determining the upper limit, which can be profitably used for the iodide concentration in the mother liquor is discussed. The recovery of the iodine represents not only the saving of a valuable by-product, but makes the operation of the evaporator house simpler, for the reason that the carbonates and a portion of the sulfates are disposed of. The iodine is liberated by means of acid and bleaching powder. The iodine is removed from the solution by means of live steam.

*A plan for incentive to research in pure and applied chemistry:* W. J. HALE. The latent possibility of the university assistantship is depicted and the ideal fellowship for the university defined. The so-called industrial fellowships for industrial ends are severely criticized. Several basic premises are drawn up and these lead directly to the conclusions that university researches should be concerned primarily with pure chemistry and not with industrial problems, else, chemical progress now so much more marked outside the academic walls will still further outrank the advancement made at our universities. Both the industrial and academic world will profit greatly through investigations in the pure science, for which universities and endowed laboratories are most favorably situated. To this end, the industries, the universities, and The American Chemical Society should bend every effort to instill the proper spirit of research in our newly graduated chemists. A brief outline of "A Plan for Incentive to Research" is given. This is based upon monetary reward for original contributions to the literature. The extent of such reward is based upon the decision of the several boards of editors of the American Chemical Society. A fund for the purpose is of course required and to this end many industries will be glad to contribute. Freedom to select any particular university and to work under the direction of a personally chosen authority is shown to be an absolute necessity for the proper growth of research talent both on the part of instructor and student.

*The economic status of the chemist:* A. M. COMEY. Discussion of average salaries received by research chemists in a number of laboratories, January 1, 1920, compared with those received January 1, 1915. Average present salaries received by research chemists in a number of laboratories according to the number of years out of college.

*Crystal growth in bearing metals:* E. G. MAHIN. It is shown in this paper that gamma tin-antimony and epsilon tin-copper crystals grow appreciably in tin base bearing metals, at temperatures at or slightly below the lower border of their temperature range of formation. Specimens of chill cast bearing metals were heated to various stated temperatures, in many cases these being immersed in glycerine to prevent oxidation. After periods varying from one to four hours the specimens were examined and the crystals were measured.

*The specific heat of petroleum at different temperatures:* F. W. BUSHONG and L. L. KNIGHT. The results obtained together with those taken from chemical literature were presented in the form of curves. They show that the specific heat of the petroleum hydrocarbons, including paraffin, is proportional to, or a function of, the absolute temperature.

*The filter press:* D. R. SPERRY. The paper described the general principle of the filter press, the different arrangements possible, the materials filter presses can be constructed of, means of feeding and piping the filter press with a discussion of pumps appropriate for handling various substances and the method of attack to be used in selecting the proper arrangement for the filtration of several widely different substances. The different filtering mediums also were discussed.

*Chemical corrosion:* D. T. SHAW. Two types of corrosion are discussed, (1) Static Corrosion, (2) Velocity Corrosion in which the corroding liquid passes across the test piece at velocities from 8 ft./min. to 1400 ft./min. Under Static Corrosion, the effect of various factors affecting the rate of corrosion was studied as follows: (1) The shape of the test piece, within reasonable limits, has no effect. (2) The volume of the corroding liquid, above a certain minimum, is without influence. (3) The effect of concentration depends upon the solubility of the metal or of the corrosion product. (4) Temperature has a profound influence, it having been proved that the logarithm of the corrosion rate varies directly as the temperature. (5) The time of exposure of the test piece to the corroding liquid must be long to eliminate initial corrosion effects. (6) The test piece after the test should be cleaned by hand polishing with some mild abrasive such as "Old Dutch Cleanser."

*A new type of catalyzer for hydrogenation:* W. D. RICHARDSON. The new type of metallic catalyzer described is the invention of Mr. Benjamin

W. Elder and is covered by U. S. Patents. It is decidedly active and the activity increases in proportion to the fineness of the abrasive used and the length of time the mill is operated. The activity curve of hydrogenation rises at first with this catalyzer and reaches a maximum before declining. The catalyst prepared by this process is certainly metallic in nature and not a sub-oxide, therefore proving that a sub-oxide nickel catalyzer is not essential for hydrogenation. Since the nickel shot has been subjected to a temperature above the melting point of nickel ( $1470^{\circ}\text{C.}$ ), it is obvious that the previous theory that high temperatures are inimical to catalytic material must be revised, although the facts in connection with the preparation of chemical catalyzer by the reduction of nickel oxide are well known, low temperatures producing active, high temperatures inactive catalysts. The Elder process is of great importance in a practical way and for the theory of catalytic action.

*Sulfites as standards for oxidizing reagents:* S. LANTZ SHENEFIELD, FRANK C. VILBRANDT and JAMES R. WITHROW. The use of sulfur dioxide gas as a standard for iodine or permanganate titration is beset with the host of troubles which are always possible when attempting to predestinate the content of a gas mixture in which one component is water soluble. This paper endeavors to point out the possibilities of using a weighable sulfite, preferably the heptahydrate of sodium sulfite which is mentioned in the literature for standardization purposes. A systematic correlation of the literature from this point of view is given.

*Crystalline structure of paraffine wax:* D. B. MAPES. A method is described for determining the structure of the wax for the purpose of ascertaining the quality in advance of the actual sweating and pressing. Paraffine distillate from petroleum is dissolved in chloroform, the solution chilled and centrifuged. The wax layer obtained is examined microscopically, while a low temperature is maintained by means of a constant temperature slide.

*Mid-continent gasoline:* C. K. FRANCIS. The characteristics and methods of determining these properties were described, applying particularly to gasoline made from petroleum and natural gas of the mid-continent district. The deposit in automobile cylinders, commonly called "carbon" is, in reality, sulphur, this substance being found in crude gasoline only in very minute quantities. But gasoline is often placed on the market with large

quantities of sulphur introduced during the process of refining.

*The relation of chemistry (analytical and thermal) to the fabrication of steel:* J. CULVER HARTZELL.

*The relation of the electric furnace to the fabrication of carbon and alloy steels with special reference to the chemical and physical changes produced:* J. CULVER HARTZELL.

*Industrial uses of activated charcoal:* O. L. BARNEBEY.

*Inclusions and ferrite crystallization in steel: II. Solubility of inclusions:* E. G. MAHIN. It was shown in an earlier paper that non-metallic inclusions undoubtedly cause separation of ferrite around them, from slowly cooling steel of hypoeutectoid composition. There was advanced to account for this action the hypothesis that the inclusion dissolves slightly in the austenite of hot steel and this lowers the solubility of ferrite and causes supersaturation of the latter first in the zone immediately surrounding the inclusion. In the present paper this hypothesis is tested by inserting metallic cylinders of various alloys and of special steels carrying abnormal per cents. of special elements, into normal steels. In nearly all cases heating to above the transformation range and slow cooling causes the appearance of a well defined ring of ferrite about the insert. This is presumed to be due to the migration of the elements of the inserts into the surrounding steel, this having an effect upon ferrite solubility similar to that of non-metallic inclusions. Lantern slides, made from actual photomicrographs, were shown to illustrate the experiments.

CHARLES L. PARSONS,  
Secretary

(To be continued)

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## SCIENCE

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